Studies of Proton Drip-Line Nuclei Using the Berkeley Gas-Filled Separator

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We have made a first measurement of proton drip-line isotopes using the Berkeley Gas-Filled Separator (BGS). To test the performance of the BGS, we measured the 360 MeV ^{78}Kr + ^{102}Pd reaction to look for the decay of ^{177}Tl. We then searched for the as-yet unobserved isotope ^{176}Tl at beam energies of 375 and 385 MeV. Our preliminary results are presented here[1].

Thallium-177 was recently measured[2] at Argonne National Laboratory's Fragment Mass Analyzer. Both the ground state (g.s.) and an isomer with observed, with cross sections of 10 nb and 30 nb, respectively. The g.s. [$T_{1/2}$ = 67(37) ms] decayed by emission of either a 1156(20) keV proton [27(13)%] or a 6907(7) keV alpha particle. The isomer decayed by emission of a 1958(10) keV proton [51(8)%] or a 7487(13) keV alpha particle with a half life of 451(106) μs. Based on the proton-decay half-life, the g.s. was assigned to a $\pi s_{1/2}$ configuration; a $(\pi h_{11/2})^{-1}$ configuration was deduced for the isomer.

The BGS is well suited for this type of measurement. It is able to withstand relatively high beam intensities, and it has large momentum and charge acceptances that result in high transport efficiencies. This is important when studying isotopes produced in very low yield. The separation of the incident beam and transfer-reaction products from fusion-evaporation reaction residues is accomplished within a few microseconds; suppression of the primary beam is ~10^{-12}. Finally, the detector system permits isotopes to be positively identified based on their decay chains.

Following magnetic separation by the BGS, the evaporation residues pass through a parallel grid avalanche counter (PGAC) and are implanted into a silicon strip detector (SSD). Signals from the PGAC permit an implantation to be distinguished from the subsequent decays. The SSD has 16 vertical strips; by comparing the magnitude of the signals measured from each end of a strip, the vertical position is determined to within 0.9 mm. Since the time between implantations at a given position was several seconds, the decay chain of an implanted evaporation residue could be tracked through several generations until known alpha decays were observed, providing identification.

Preliminary analysis of the 360 MeV data has revealed two events which are ^{177}Tl candidates. One is from the isomer, one from the g.s.; in both cases, a proton decay with the appropriate energy is correlated with subsequent alpha decay(s) of the ^{176}Hg alpha decay chain. Additionally, five time- and position-correlated chains have been observed with alpha decay energies corresponding to the decay of ^{174}Hg and its daughter, ^{170}Pt. Since ^{174}Hg has only been observed in very low yield previously[3], this result is encouraging. Analysis of the higher energy bombardments is in progress. These results, combined with the recent improvements to the detector and data acquisition systems, indicate that the BGS will be an excellent tool for the investigation of proton drip-line nuclides.

Footnotes and References

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1. For a more detailed account see M. W. Rowe, *et al.*, Proc. of Int. Symp. on Proton-Emitting Nuclei, Oct. 7-9, 1999, Oak Ridge, TN (to be published by APS Press).
2. G. L. Poli, *et al.*, Phys. Rev. **C 59**, R2979 (1999).
3. Seweryniak, D., *et al.*, Phys. Rev. **C 60**, 1304 (1999).